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Numerical Studies of ILC Positron Target Operation in OMD Magnetic Field

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DOE Review

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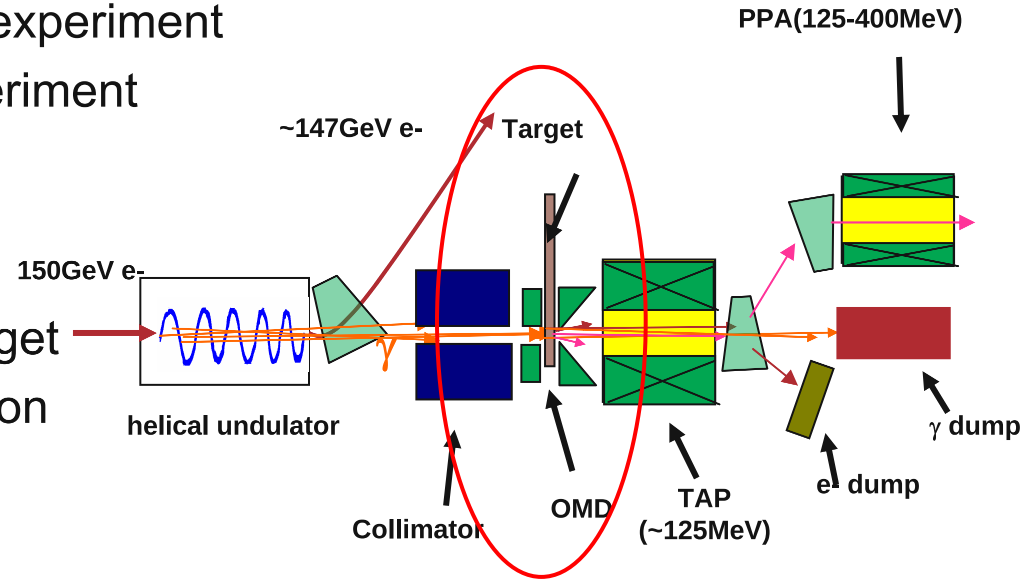
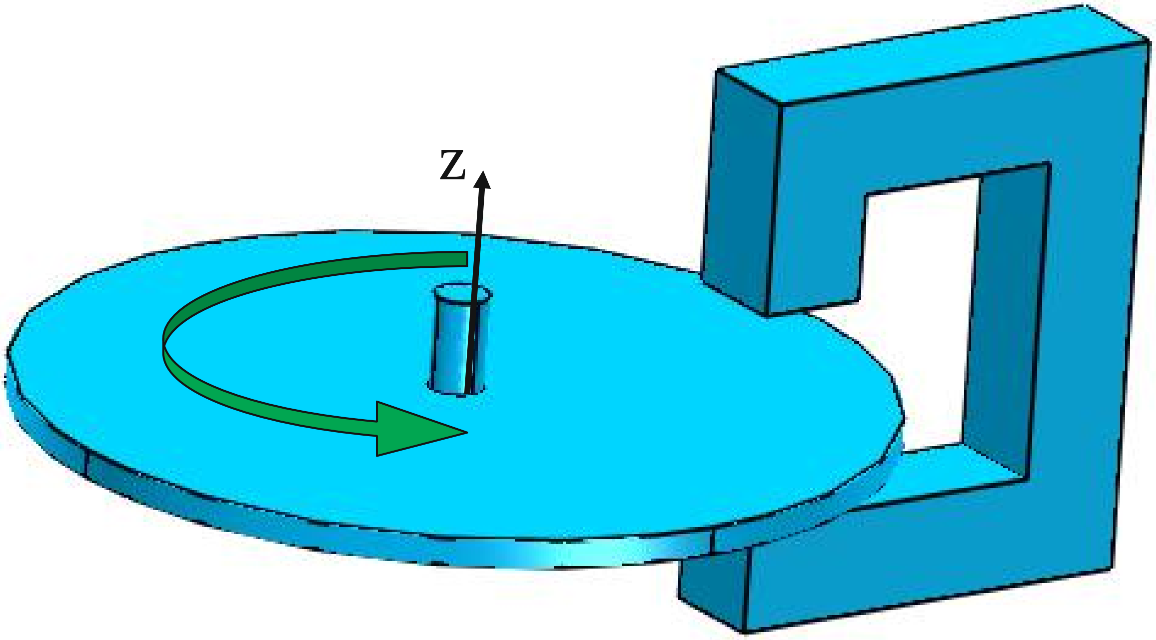
Positron target simulation request from ILC design committee

- Simulate a target rotation in presence of Optical Matching Device field
- Magnetic field on the target 5 Tesla
- Rotation rate 1000 rpm
- Target conductivity ~ 1.5e6 (copper - 6e7)
  - Benchmark against SLAC/LLNL experiment
  - Simulate Cockroft prototype experiment
  - Simulate a full-scale ILC target

- Power requirements to spin the target
- Other effects associated with rotation



Model for simulation



Conducting disk (target) rotates in the constant magnetic field of ***arbitrary*** distribution.

Eddy currents are produced. Find their distribution, induced magnetic field etc depending on rotational frequency and geometry

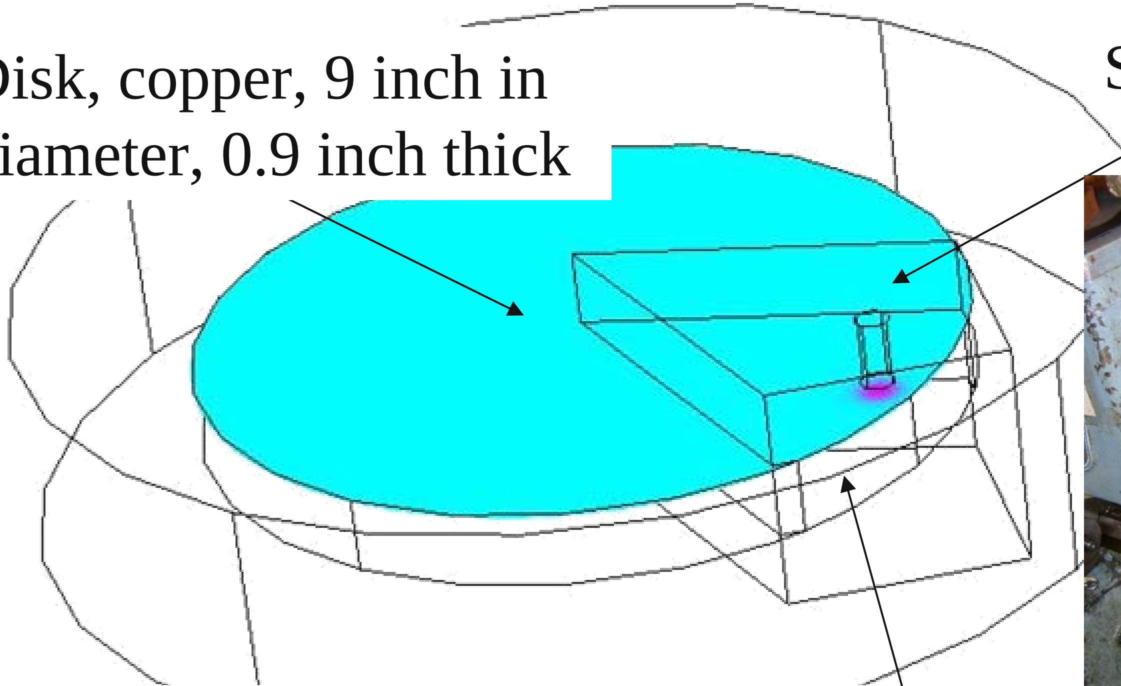
$$\nabla^2 \vec{B} + \sigma \cdot \mu \cdot \mu_0 \cdot \nabla \times \left[\vec{v}, \vec{B} + \vec{B}_0 \right] = 0$$

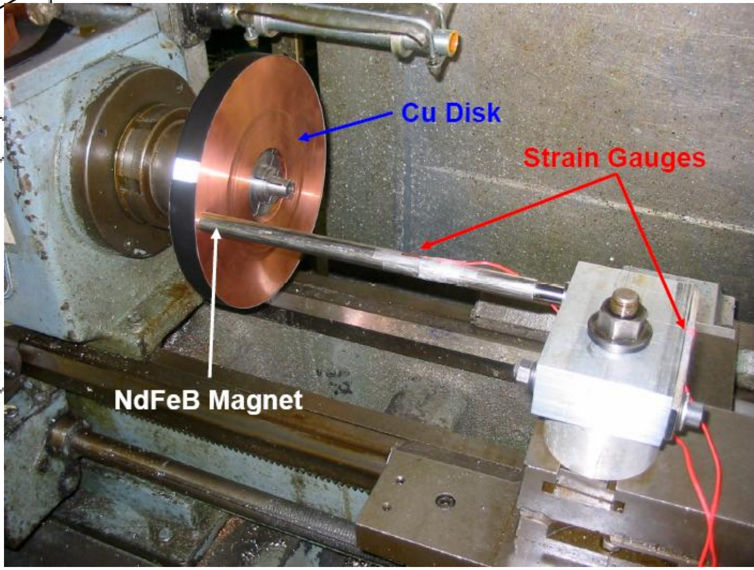
$\vec{v} = \omega \cdot \{-y, x, 0\}$ Velocity, B_0-external, B-induced magnetic field

SLAC/LLNL experiment simulation: geometry

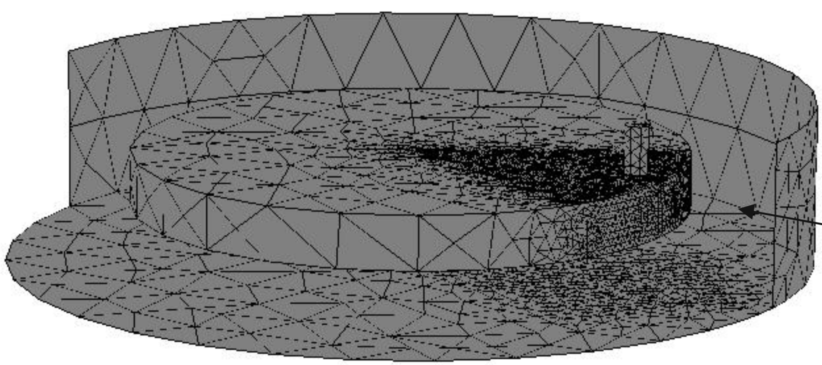
Disk, copper, 9 inch in diameter, 0.9 inch thick

Single pole



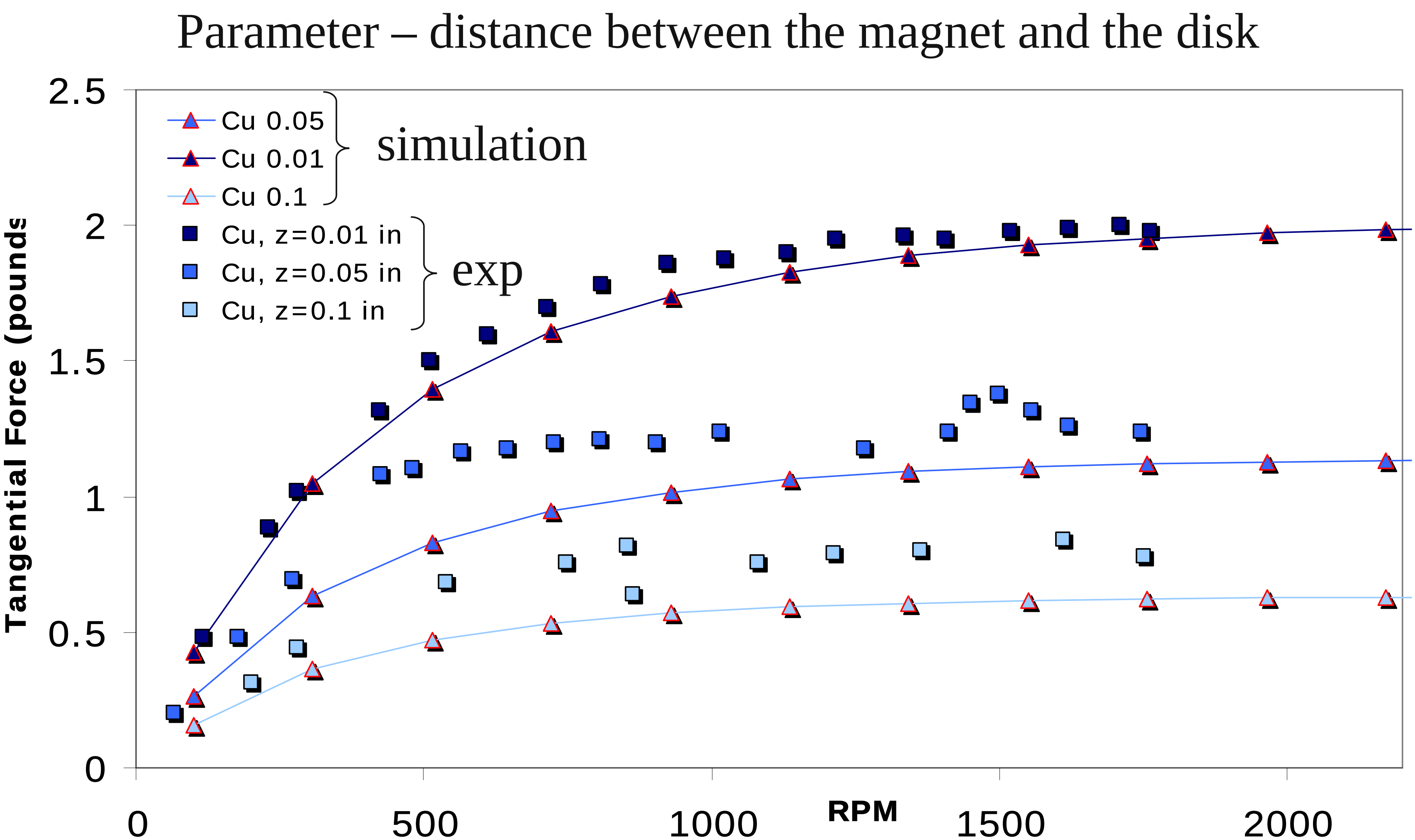


W. T. Piggott, S. Walston, D. Mayhall "Preliminary Investigations of Eddy Current Effects on a Spinning Disk." LLNL report. Sept. 2006.



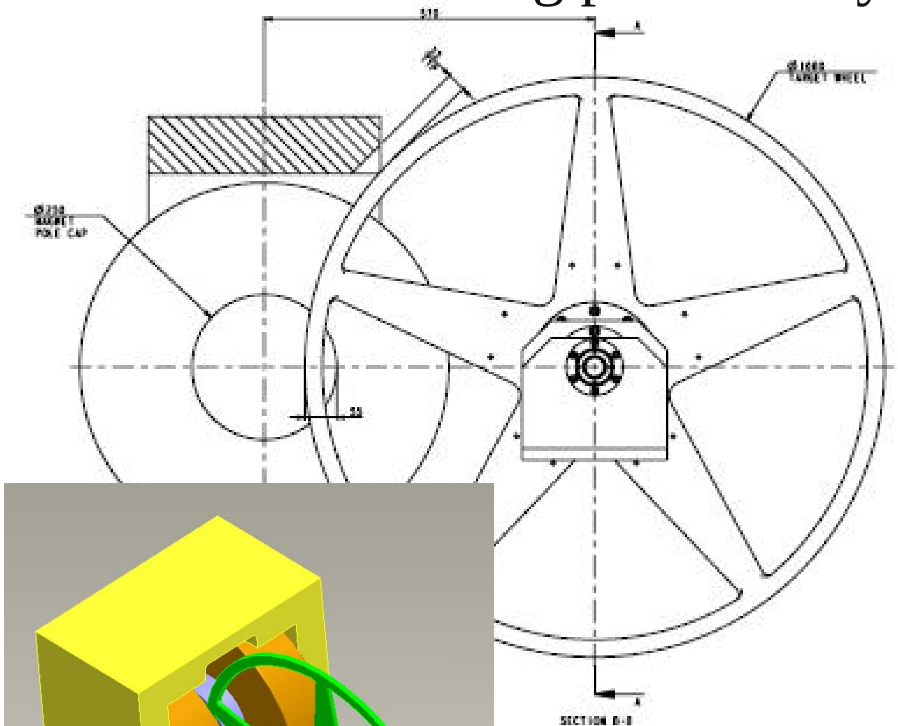
Artificial subdomain to improve mesh quality

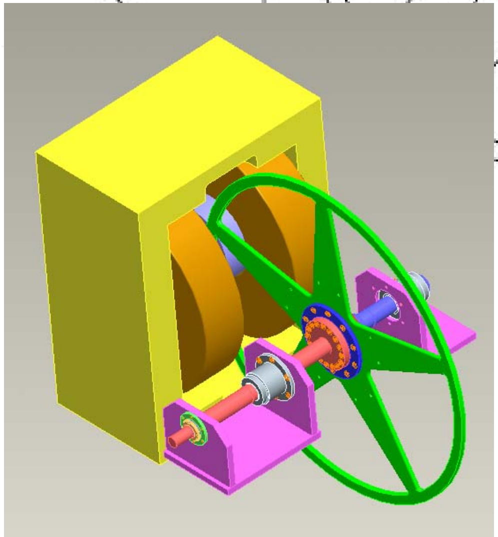
Results comparison

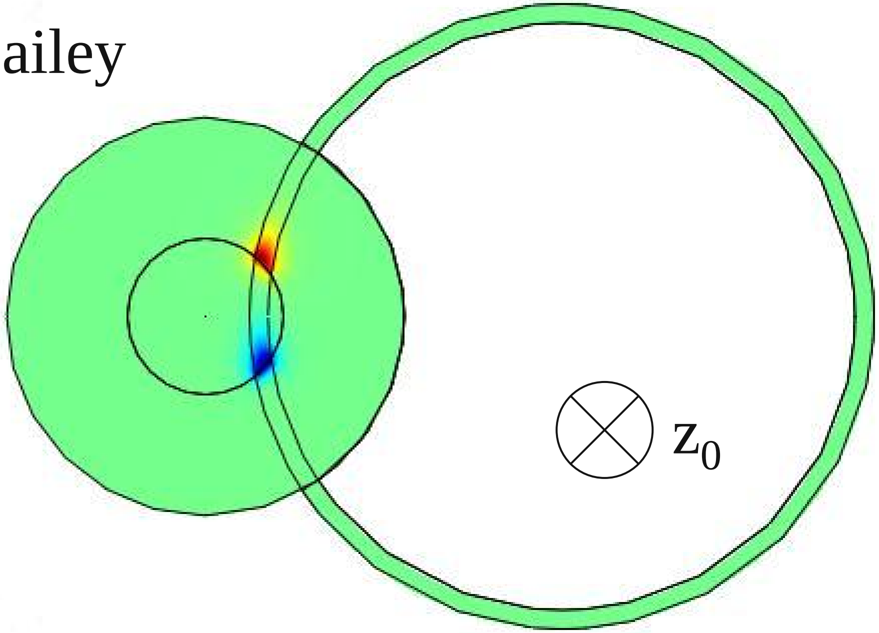


Cockroft institute prototype experiment simulation

Technical drawing provided by I.Bailey

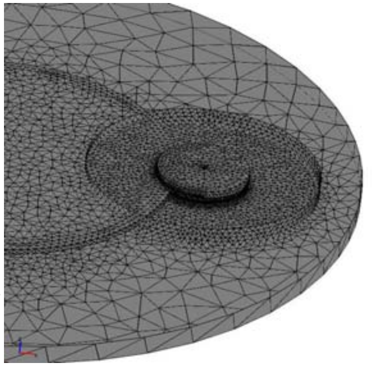




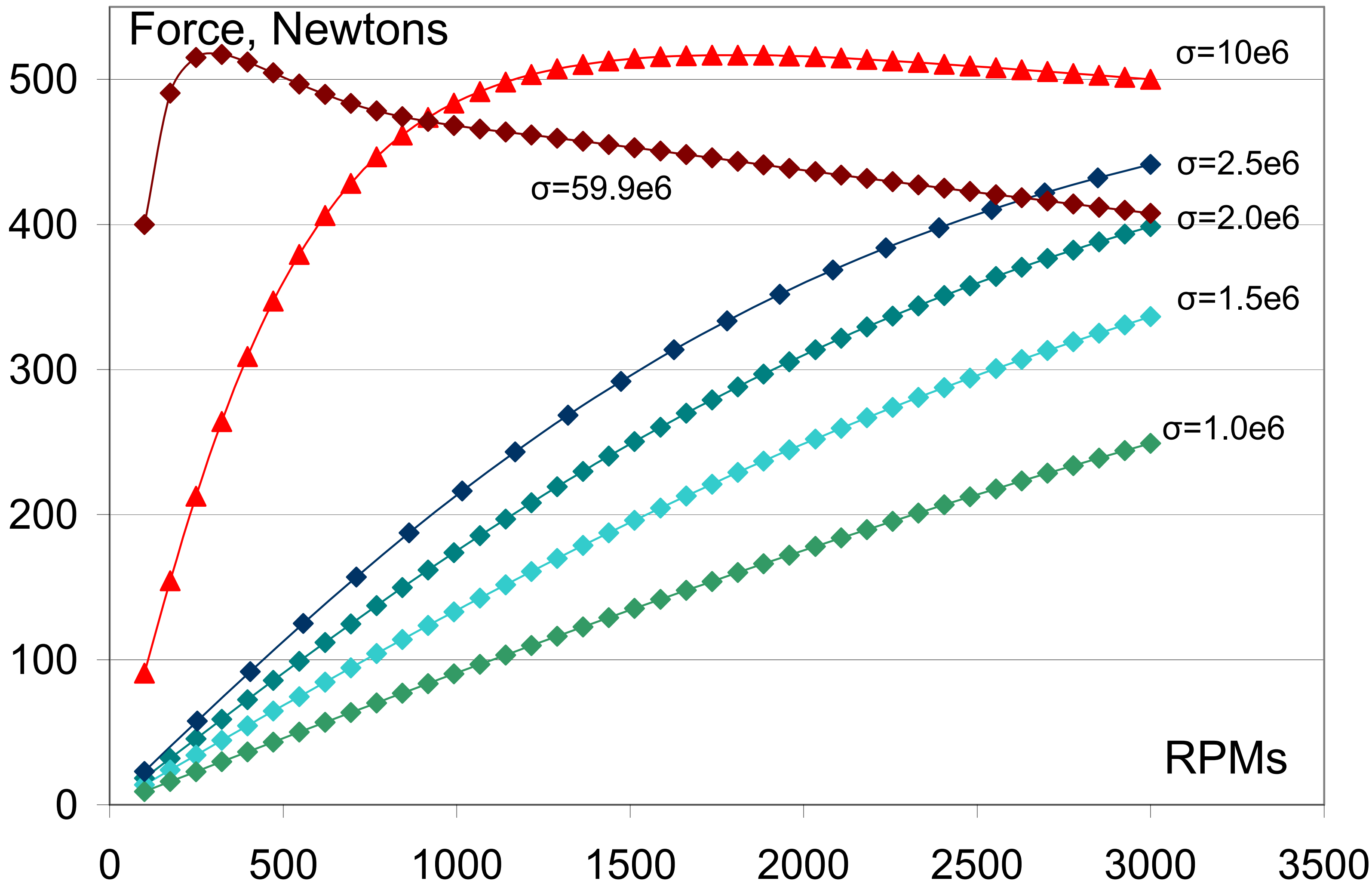


Simulation, Induced field, z-component, 2000RPM

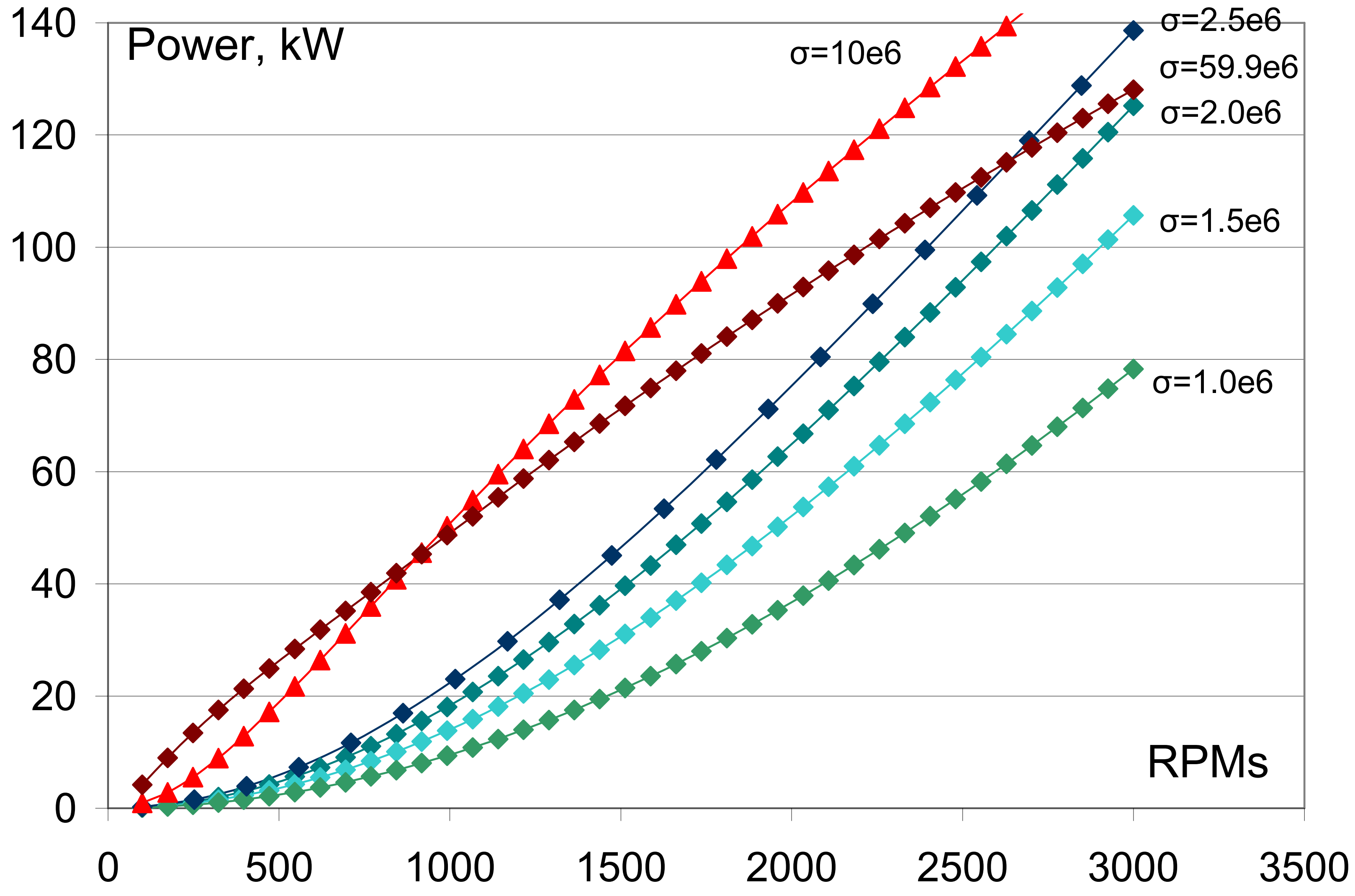
D – 1m, rim width – 30mm, rim thickness – 14mm, distance between magnet poles is 5cm, field – 1.5Tesla



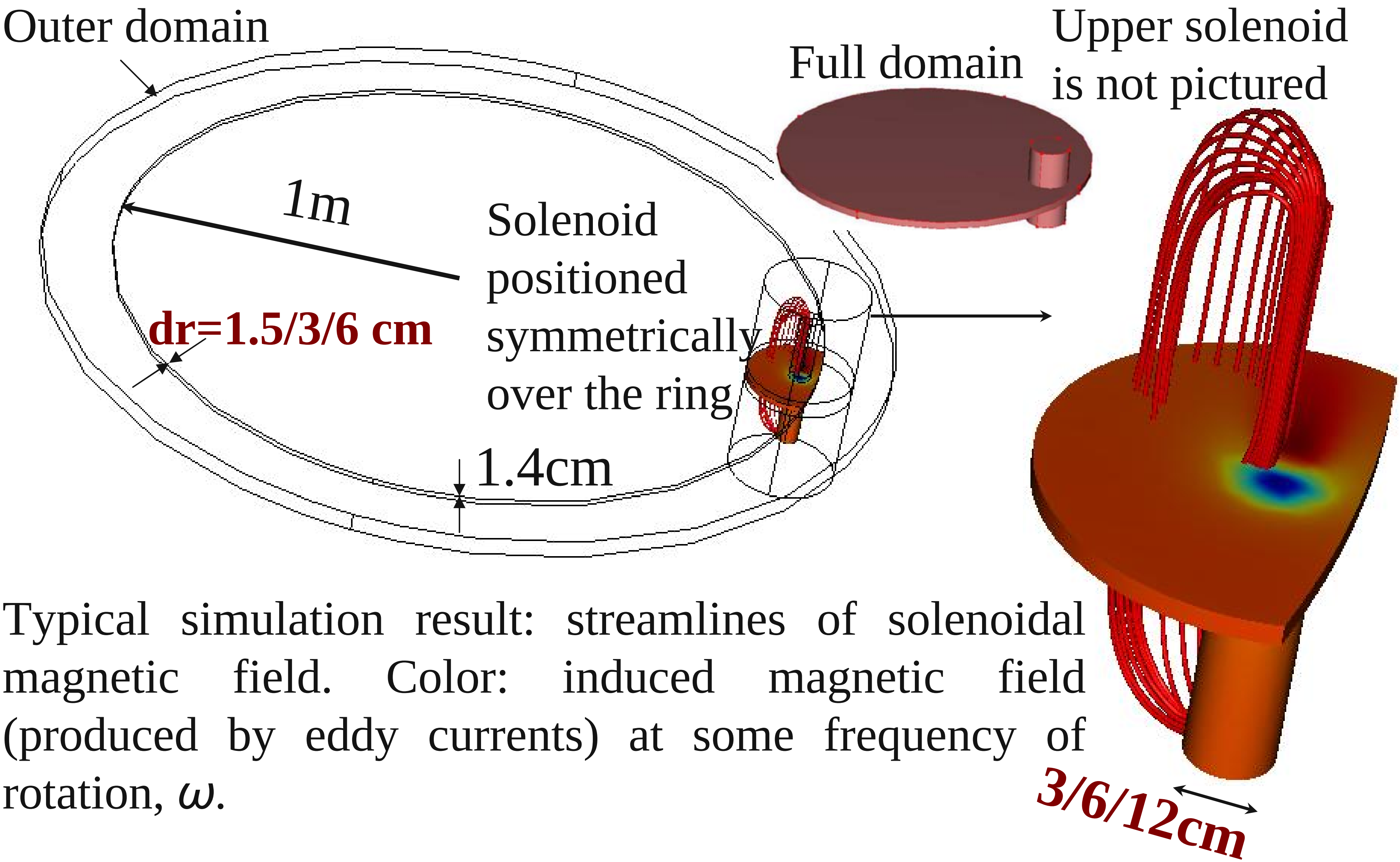
Simulation results: drag force for various conductivities



Simulation results: power requirement for various conductivities



ILC target simulation geometry



Typical simulation result: streamlines of solenoidal magnetic field. Color: induced magnetic field (produced by eddy currents) at some frequency of rotation, ω.

Results for σ =1.5e6 @910rpm, 5Tesla

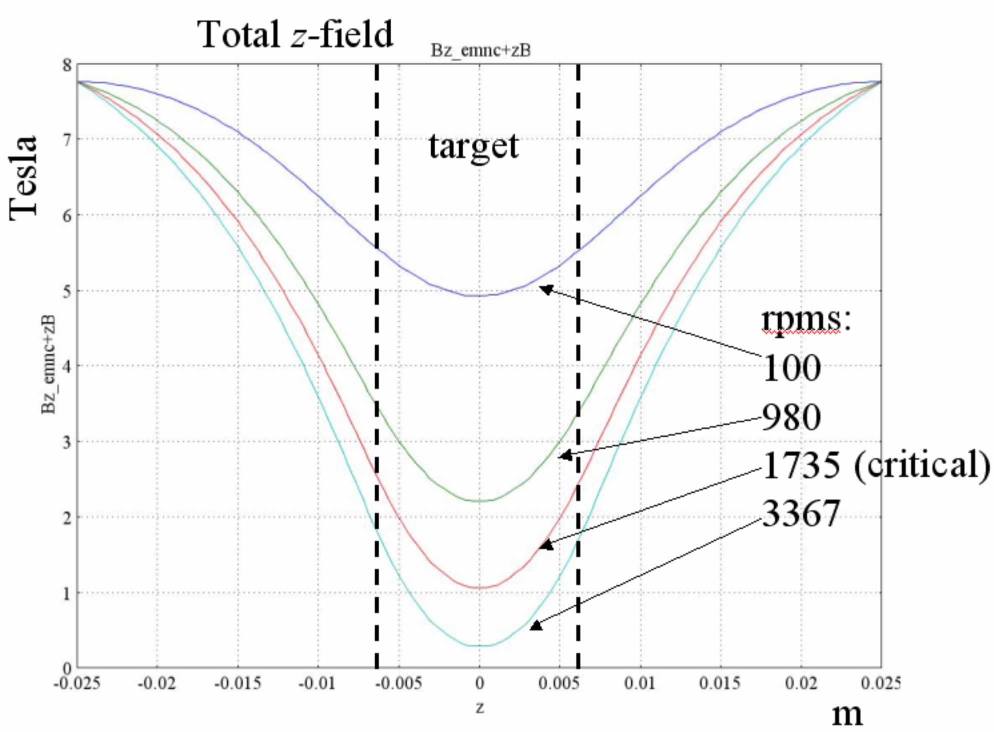
Ring width

Magnet aperture

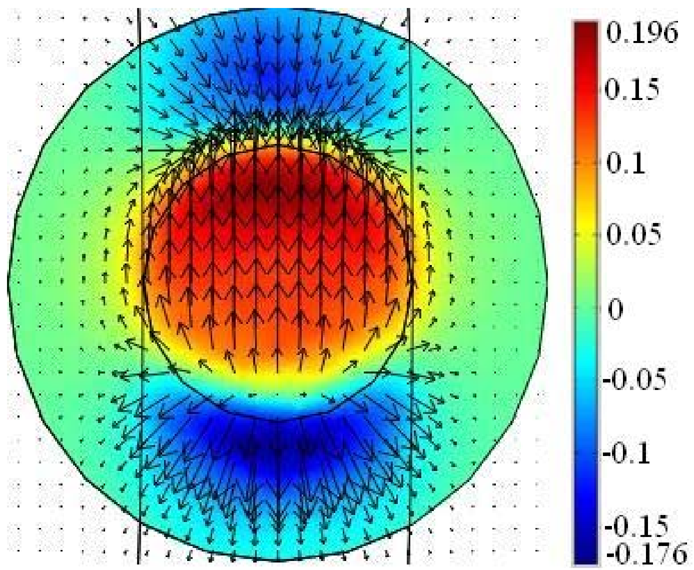
	1.5cm	3cm
3cm	170kW@910rpm	332kW@910rpm
6cm	172kW@910rpm	433kW@910rpm
12cm	175kW@910rpm	463kW@910rpm

The power requirement will be even smaller for pulsed OMD

Field cancellation effect and deflection of the beam



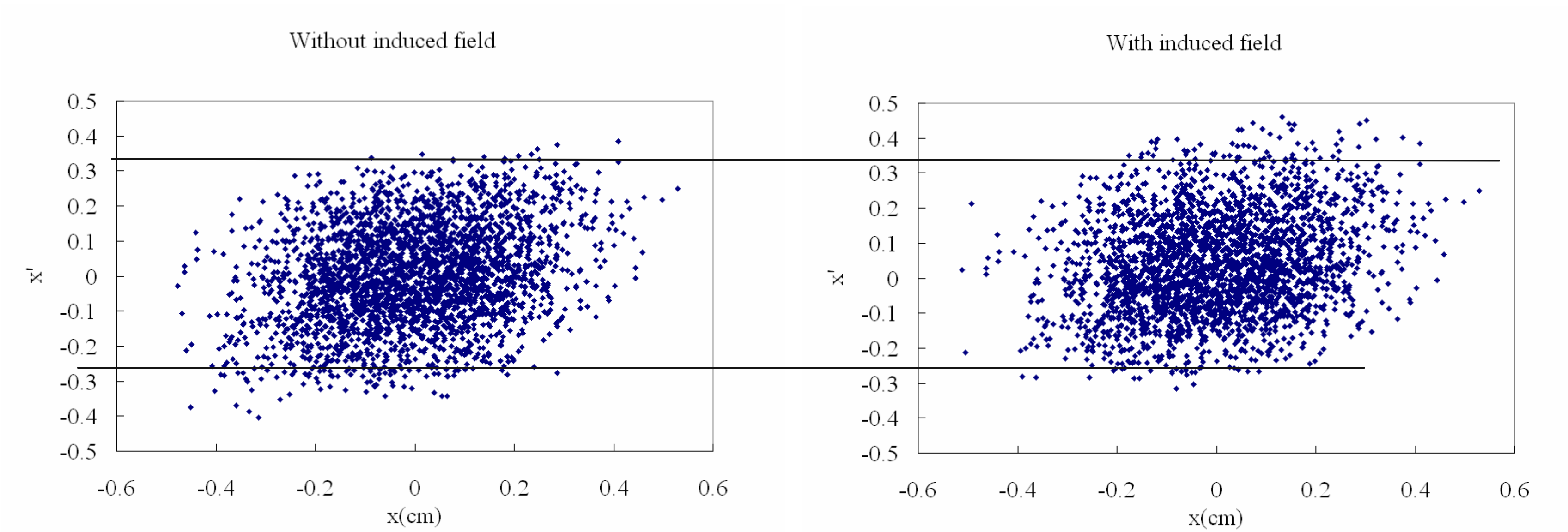
Deflecting field



Induced field reduces the total field on the face of the magnet (5→2Tesla at 1000)

Eddy currents produce deflecting field which will deflect the beam by ~10mm

Initial x-x' of captured positrons



- Induced field kicked some positrons out but also kicked some in. The lost of yield is only ~5%(from ~1.27 down to ~1.20) for σ=3e6.
- For σ=1.5e6, since the eddy current induced field is small compared with the OMD field, and also due to the broad band matching provided from OMD field, the distortion of field does not cause any noticeable change to the e+ yield.

Summary

- We developed a model to guide the ILC positron target design
- Succesfully checked against the SLAC/LLNL experiment
- The exact simulations of ILC positron target were performed
- Parametric studies were made to guide further design of the target
- Effects associated with the target rotation in OMD field were simulated

- Future plan: make a TD/FD simulation for pulsed OMD